

# Testing Summary of the Analog Transient Waveform Digitizers for the KamLAND Experiment

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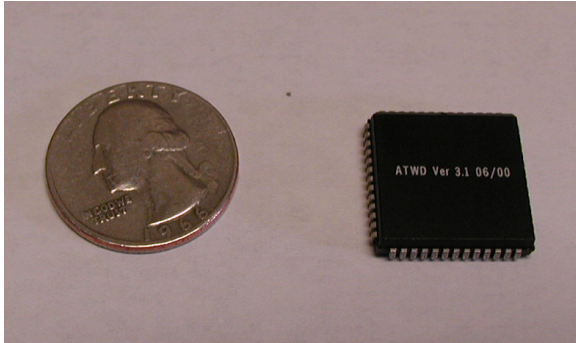


Figure 1: This photograph shows the ATWD sitting next to a quarter.

The Kamioka Liquid scintillator Anti-Neutrino Detector (KamLAND), currently under construction in Japan, is a long baseline neutrino oscillation experiment which uses Japanese commercial nuclear power reactors as the neutrino source in its first phase. In the KamLAND detector approximately 4000 Analog Transient Waveform Digitizer (ATWD) ATWDs will be used to digitize the charge signals from the 2000 20-inch photomultiplier tubes (two ATWDs will be used for each PMT). It was necessary to characterize the ATWDs and to develop a mass testing procedure for them to insure that they function properly within the desired range.

Each of the ATWDs has four channels. In the KamLAND electronics, three of these will be used for PMT pulses (one high gain channel, one medium gain channel, and one low gain channel) and the fourth will be used for timing signals. We will refer to these channels as H, M, L, and X in this document. Each of the four channels has 128 time bins. A photograph of an ATWD chip is shown in Figure 1.

The testing board was fabricated from an existing 12-channel KamLAND prototype data acquisition board. The board was modified to power the ATWDs from an external source (to monitor the current consumption) and to include

a computer-controlled pulser. The pulser could provide both very broad pulses (which would cover the entire ATWD digitization time) and high frequency pulses (approximately 20 MHz).

The custom testing software program was written by Sanshiro Enomoto, a Tohoku University graduate student. For the testing it was desired to study the power consumption, pedestal shape, linearity of response, gain, time response, and cross talk between channels for all ATWDs. These tests were applied to all four channels. In the testing program, data is collected and the chips must pass 10 criteria. If a chip passed all of the criteria, it was considered to be acceptable. If a chip failed one of the 10 criteria, it was rejected and the number of the first test it failed appeared on the screen so that chips with common failure modes could be separated.

Two different batches of silicon were tested, a test batch from June 2000 and the full production batch from April 2001. The June batch contained 724 chips which were tested with 581 (80.2%) of these chips passing on the tester. The April 2001 batch had 7744 chips tested, with 6117 (79.0%) passing the test criteria. It was noted that the two batches have slightly different gains. Therefore, only chips from the April 2001 will be used in the KamLAND electronics. The most common failure modes were a bad RMS on the pedestal shape or a bad power consumption. All of the failed chips have been sorted and stored according to their failure mode. If at some later date it is decided to relax some of the test criteria, it will be possible to retest the chips which failed that particular test.

## References

- [1] Marino, A. D., "Testing Procedure for the Analog Transient Waveform Digitizers", May 2001
- [2] Marino, A. D., "KamLAND ATWD Testing Summary", Oct 2001